Reflecting Costs and Benefits Within Efficiency and Renewable Energy Technology Policy Scenarios

John A. "Skip" Laitner

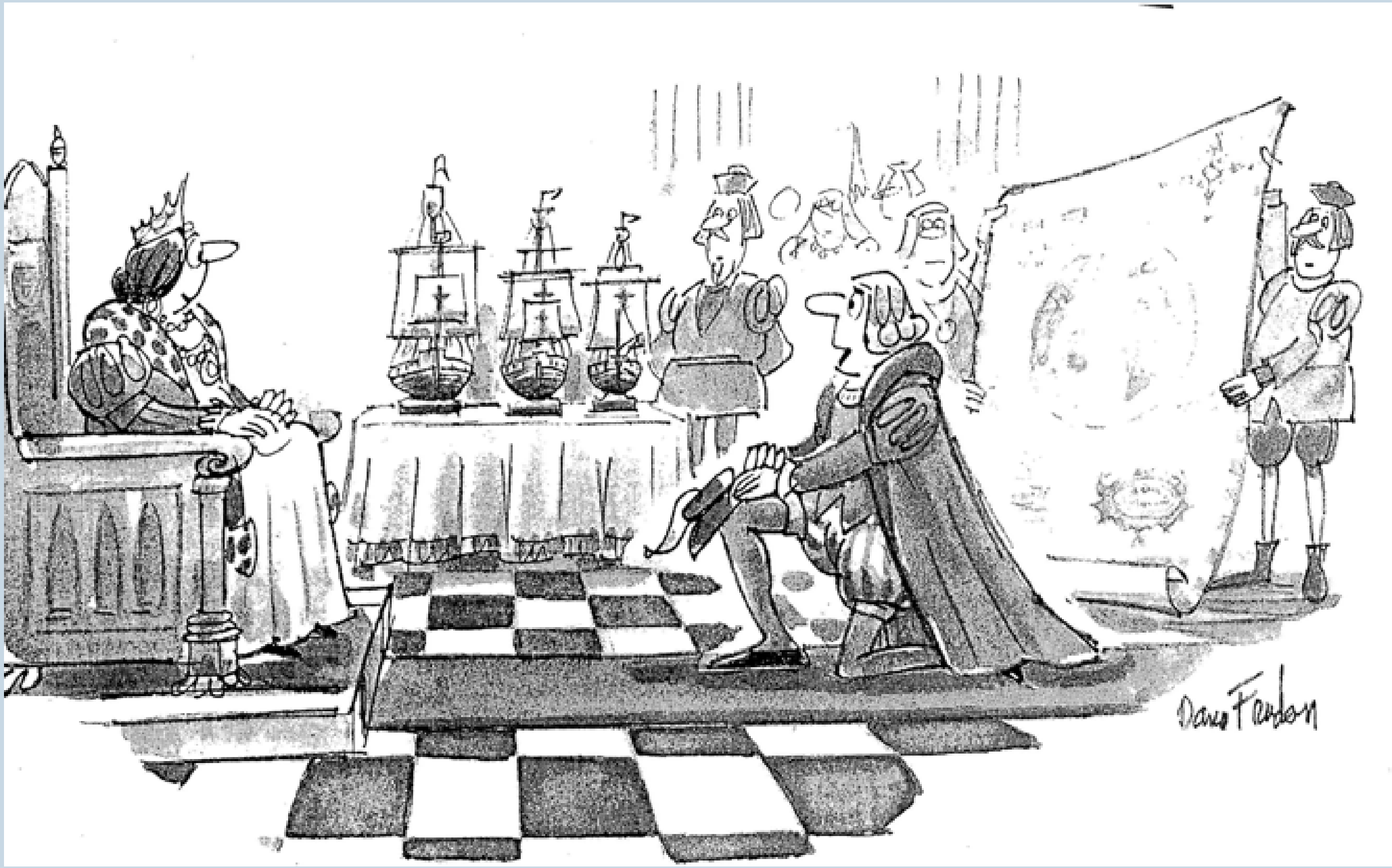
Senior Economist for Technology Policy

EPA Office of Atmospheric Programs

DG Renewable Technology Modeling Summit

Washington, DC

June 13, 2003

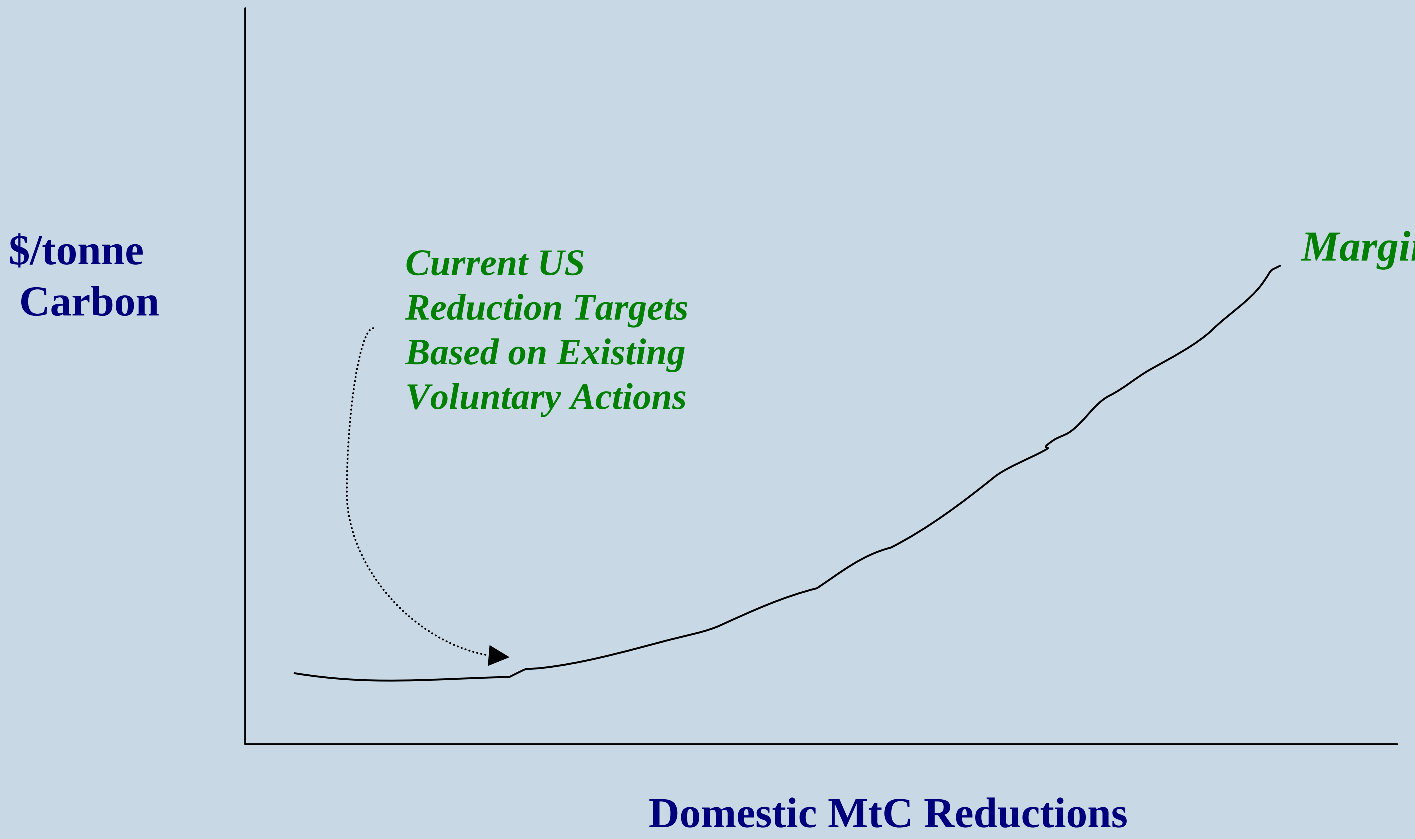


"Your Majesty, my voyage will not only forge a new route to the spices of the East, but it will also increase the productivity of your fleet by 3.2 percent."

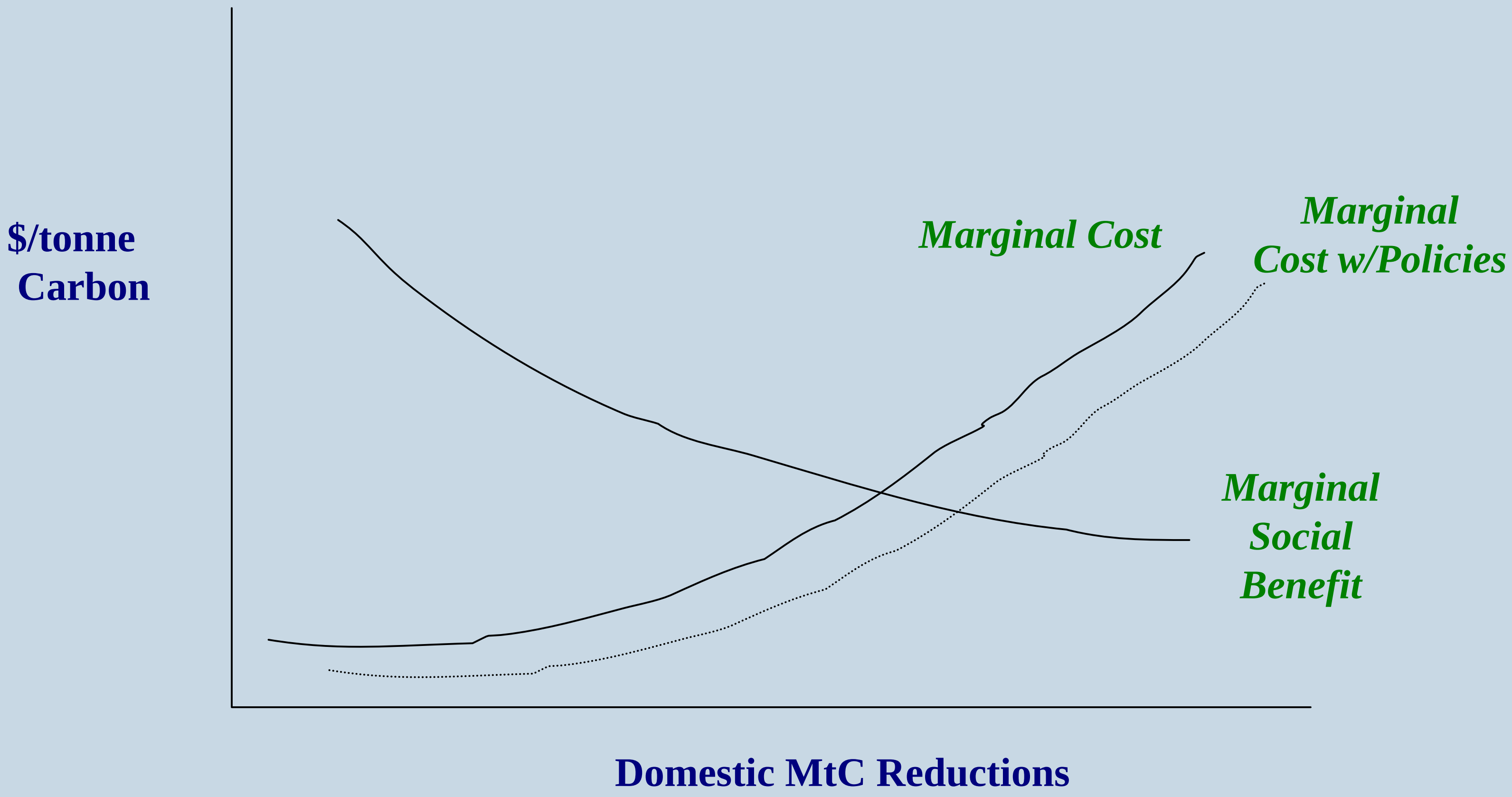
Presentation Outline

- Concepts, Categories, and Definitions
- A Technology Choice Algorithm
- Illustrative Scenario Impacts
- Preliminary Conclusions

Re-examining the Conventional Abatement Cost Curve



Yet a Different Result Emerges Using Costs <u>and Benefits</u>



In Making the Tough Choices

Individuals have a natural tendency to choose from an *impoverished option bag.* Cognitive research in problem solving shows that individuals usually generate only about 30 percent of the total number of potential options on simple problems, and that, on average, individuals miss about 70 percent to 80 percent of the potential high-quality alternatives (emphasis in the original).

Dr. Jeffrey S. Luke
***Catalytic Leadership: Strategies for an Interconnected World*, 1998**

The Economic Costs and Benefits of Energy Technology Investments

- **At Least Four Categories of Costs**
  - Direct Investment Costs
  - Operating and Maintenance Costs
  - R&D and Program Costs
  - Transaction and Search Costs
- **But Also at Least Four Categories of Benefits**
  - Direct Savings from Lower Compliance Costs
  - Process Efficiency and other Productivity Gains
  - Environmental Benefits not Captured within normal Market Transactions
  - Spillovers and/or learning created/induced by either the technology investment, or the R&D efforts

Direct Energy Savings May Be Only Part of the Full Economic Story

- For example, a review of 52 industrial energy efficiency improvements, for which reasonably detailed data was available, showed a total of:
  - $54.2 million in combined efficiency upgrades
  - Saving $12.9 million in avoided energy costs, implying a 4.2 year simple payback
  - But with savings of another $15.7 million in other productivity benefits, for a total savings of $28.6 million, the full project payback fell to 1.9 years

Source: Hodayah Finman, and John A. "Skip" Laitner. "Industry, Energy Efficiency and Productivity Improvements," *Proceedings of the ACEEE Industrial Summer Study*, American Council for an Energy-Efficient Economy, Washington, DC, August 2001.

Categories of Non-Energy Benefits

Waste	Emissions	Maintenance and Operating
Use of waste fuels, heat, gas	Reduced dust emissions	Reduced need for engineering controls
Reduced product waste	Reduced CO, CO2, NOx, SOx emissions	Lowered cooling requirements
Reduced waste water	Lower compliance costs	Increased facility reliability
Reduced hazardous waste		Reduced wear and tear on equipment/machinery
Materials reduction*		Reductions in labor requirements
Production	**Working Environment**	**Other**
Increased product output/yields	Reduced need for personal protective equipment	Decreased liability
Improved equipment performance	Improved lighting	Improved public image
Shorter process cycle times	Reduced noise levels	Delaying or Reducing capital expenditures
Improved product quality/purity	Improved temperature control	Additional space
Increased Reliability in production	Improved air quality	Improved worker morale

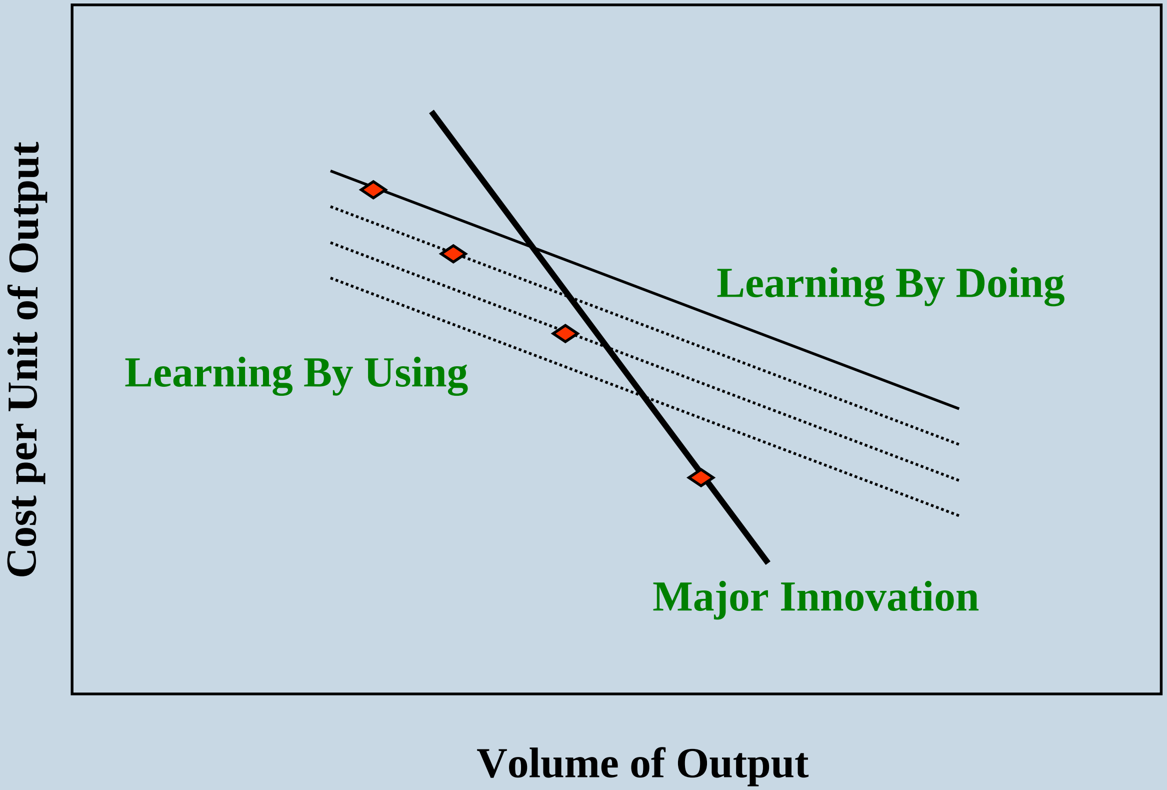
Source: Hodayah Finman, and John A. "Skip" Laitner. "Industry, Energy Efficiency and Productivity Improvements," *Proceedings of the ACEEE Industrial Summer Study*, American Council for an Energy-Efficient Economy, Washington, DC, August 2001.

A Typical Accounting of Benefits and Costs

	Costs	Benefits
Market	***Accounted***: Investments and O&M expenditures ***Unaccounted***: transaction and search costs	***Accounted***: Energy savings, lower compliance costs ***Unaccounted***: Non-Energy Benefits
Non-Market (Externalities)	Program and R&D expenditures, environmental impacts	Spillover, learning, economies of scale and scope

Note: the term "***Accounted***" refers to those costs or benefits that are typically included in net present value calculations. "***Unaccounted***" refers to costs that may be known within the existing regime of prices, but may not necessarily be included in a full cost-benefit analysis.

Dimensions of Technology Cost and Performance Improvements



A Technology Choice Algorithm to Explore Changes in Costs and Market Shares

Model and Scenario Results are Adapted from: John A. “Skip” Laitner and Alan H. Sanstad, “Learning-by-Doing on Both the Demand and the Supply Sides: Implications for Electric Utility Investments in a Heuristic Model,” *International Journal for Energy Technology Policy*, 2003 (forthcoming).

Setting Up a Heuristic Model Using a Standard Analytical Framework

- Evaluating electricity trends over the period 2002 through 2032.
- Drawing largely from the standard data and technology assumptions found in the EIA's *Annual Energy Outlook 2002* as they might be extended through the year 2032.
- Includes reference case growth and price information, only allowing changes in technology costs as they are impacted by rates of learning and non-energy benefits. Externalities are not included here.

Key Scenario Working Assumptions

Initial Busbar Cost ($/kWh)

- Defender: $0.04
- Challenger: $0.06
- Adv Challenger: $0.10
- Efficiency: $0.06

Progress Ratios

- Defender: 0.95
- Challenger: 0.90
- Adv Challenger: 0.85
- Efficiency: 0.85

Non-Energy Benefits ($/kWh)

- Defender: $0.000
- Challenger: $0.005
- Adv Challenger: $0.008
- Efficiency: $0.010

Other Key Assumptions

- Annual depreciation of existing capital stock: 3.3%
- Annual growth rate of electricity consumption: 1.9%
- Year 2002 average cost per kilowatt-hour: $0.066 (in 2000 dollars)
- Year 2002 transmission, distribution, and administrative costs per kWh: $0.026 (in 2000 dollars)
- Non-learning component of total busbar cost per kWh: $0.025 (in 2000 dollars).

Note: the results of this scenario comparison are preliminary with additional work expected to vary the final technology market shares and consumer expenditures.

Market Share Algorithm

$$MS_{kt} = \frac{COST_{kt}^{-v}}{\sum_{k=1}^{J} COST_{kt}^{-v}}$$

Where:

MS_{kt} = market share of technology k at time t

$COST_{kt}$ = amortized capital and operating costs plus the non-energy benefits of technology k at time t

v = variance parameter representing cost homogeneity

J = number of technologies competing to provide the same service as k.

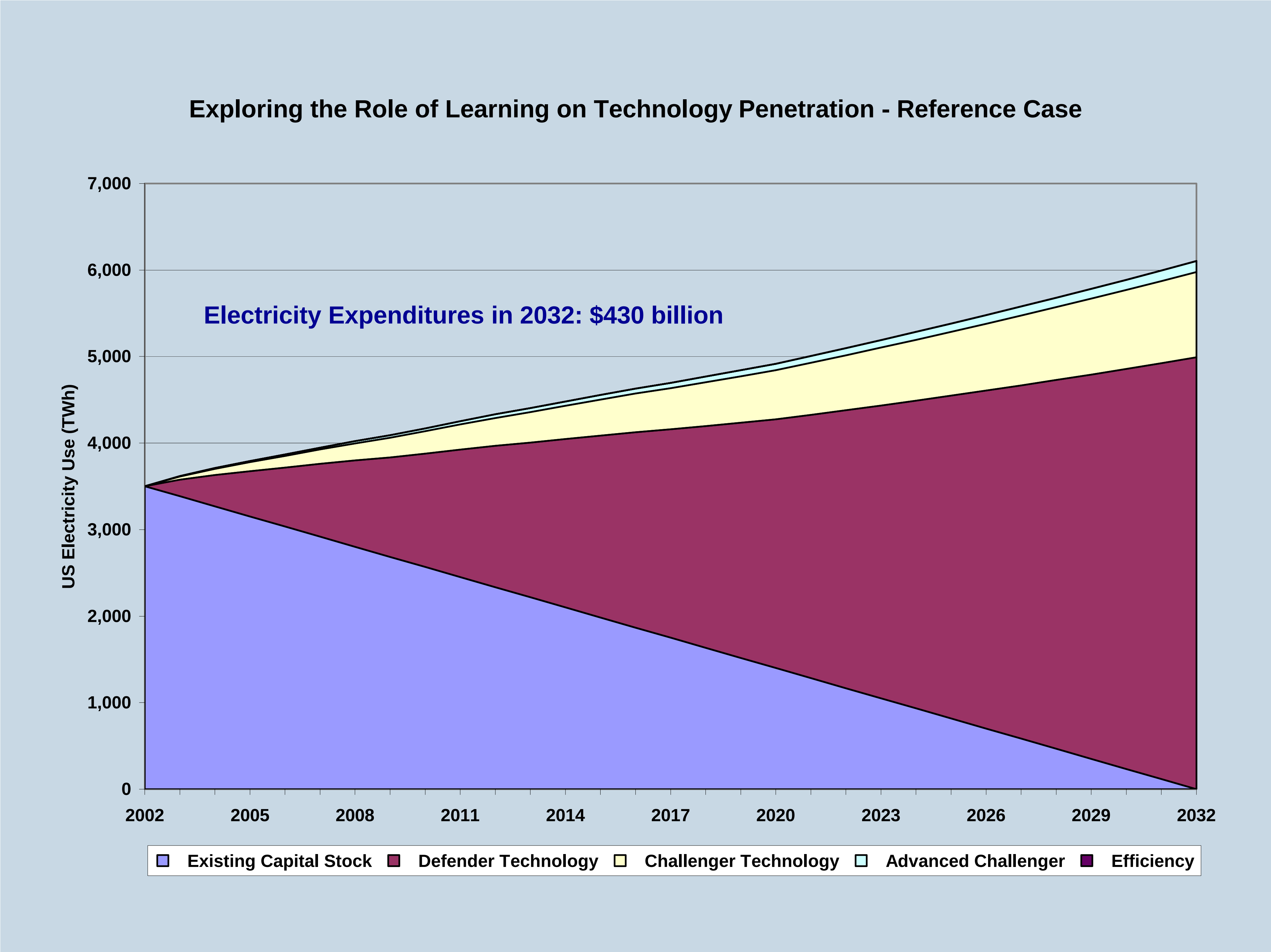
Explaining the Variance Parameter

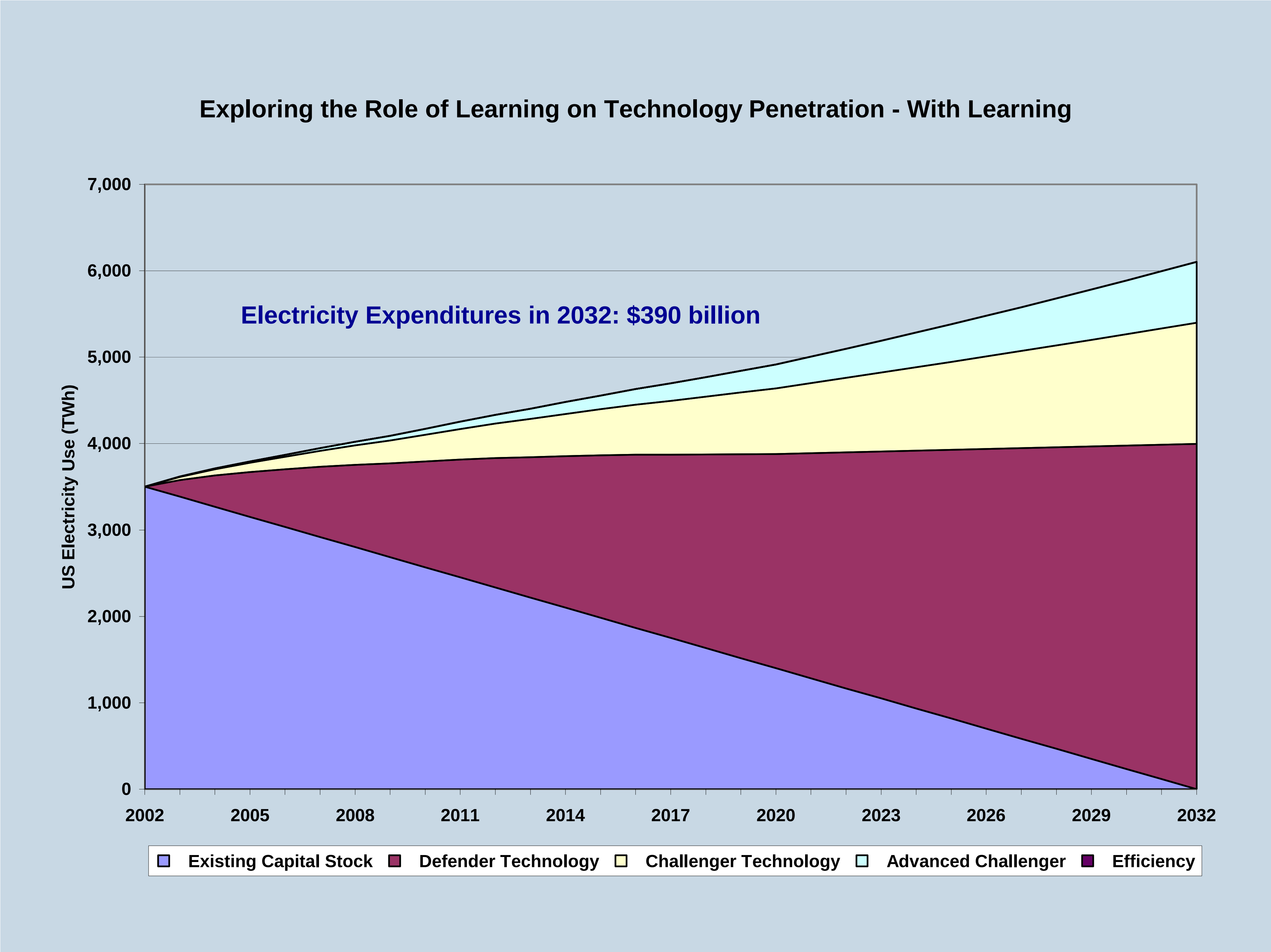
- For the variance parameter, *v*, an extremely low value, such as 1, means that new equipment market shares are distributed almost evenly among all competing technologies, even if their annual costs differ significantly.
- An extremely high value, such as 10, means that the most cost effective equipment gains a proportionately higher market share.
  - For example, a technology with a 25 percent cost advantage would grab 90 percent of market share.
- In this exercise, we adopt a value of 4.
  - In this case, a technology with a 25 percent cost advantage would grab 71 percent of the market share.

Illustrative Scenario Impacts

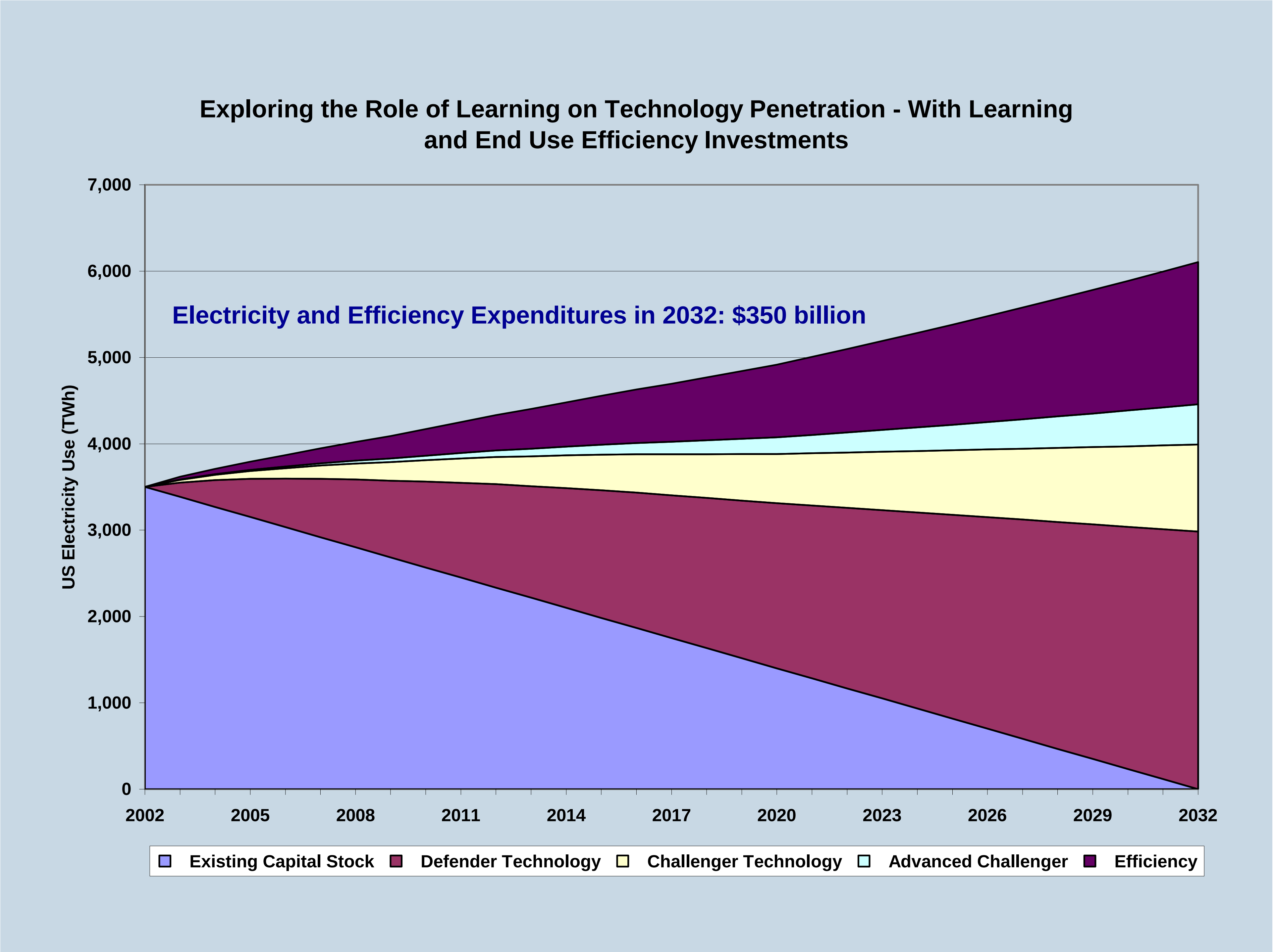
Comparing Technology Costs over Time
(including both learning and non-energy benefits)

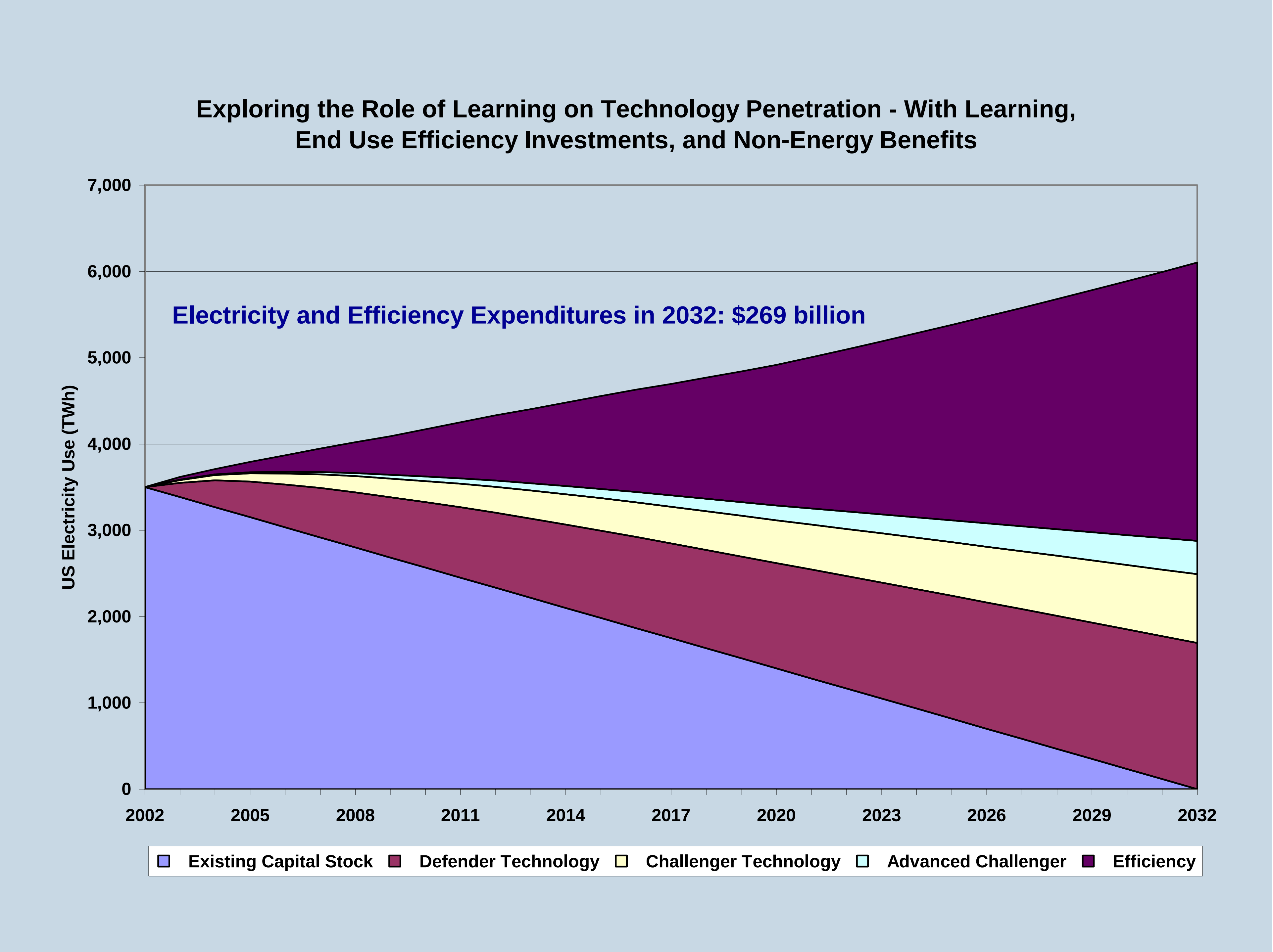
Technology Busbar Cost/kWh	Yr 2003	Yr 2032
Old	$0.040	$0.038
Defender	$0.040	$0.038
Challenger	$0.060	$0.042
Advanced Challenger	$0.100	$0.044
Efficiency	$0.060	$0.027


Exploring the Role of Learning on Technology Penetration - Reference Case
Electricity Expenditures in 2032: $430 billion
US Electricity Use (TWh)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
2002
2005
2008
2011
2014
2017
2020
2023
2026
2029
2032
Existing Capital Stock
Defender Technology
Challenger Technology
Advanced Challenger
Efficiency

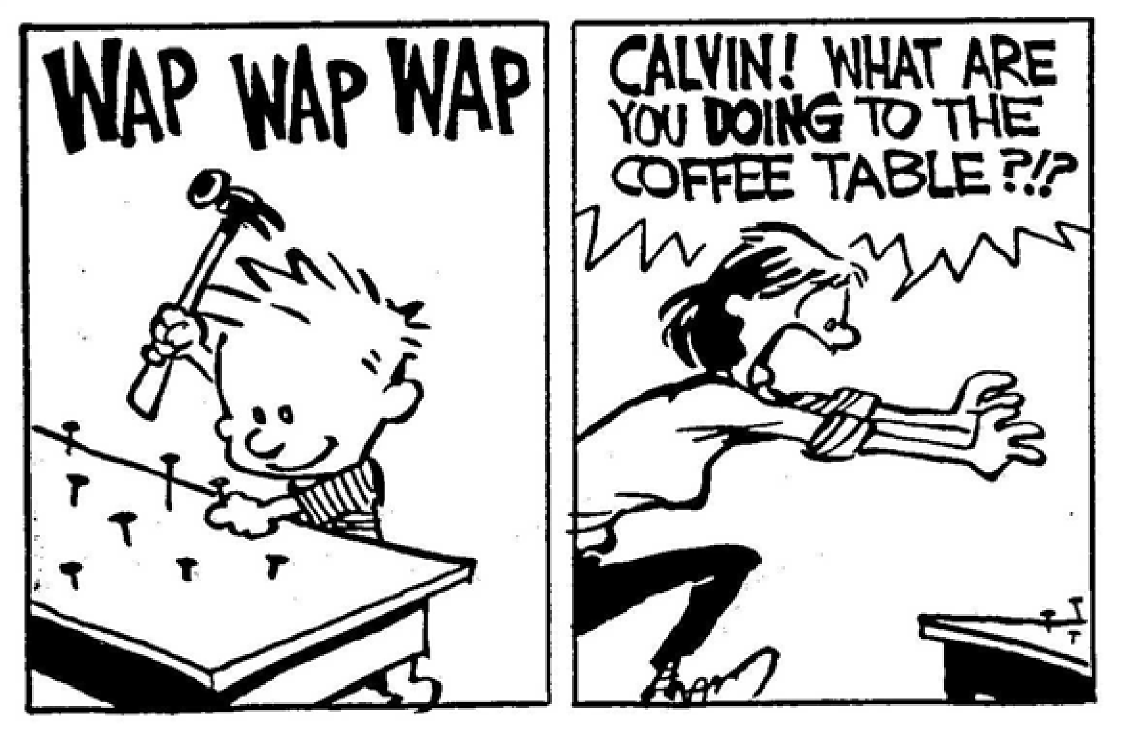


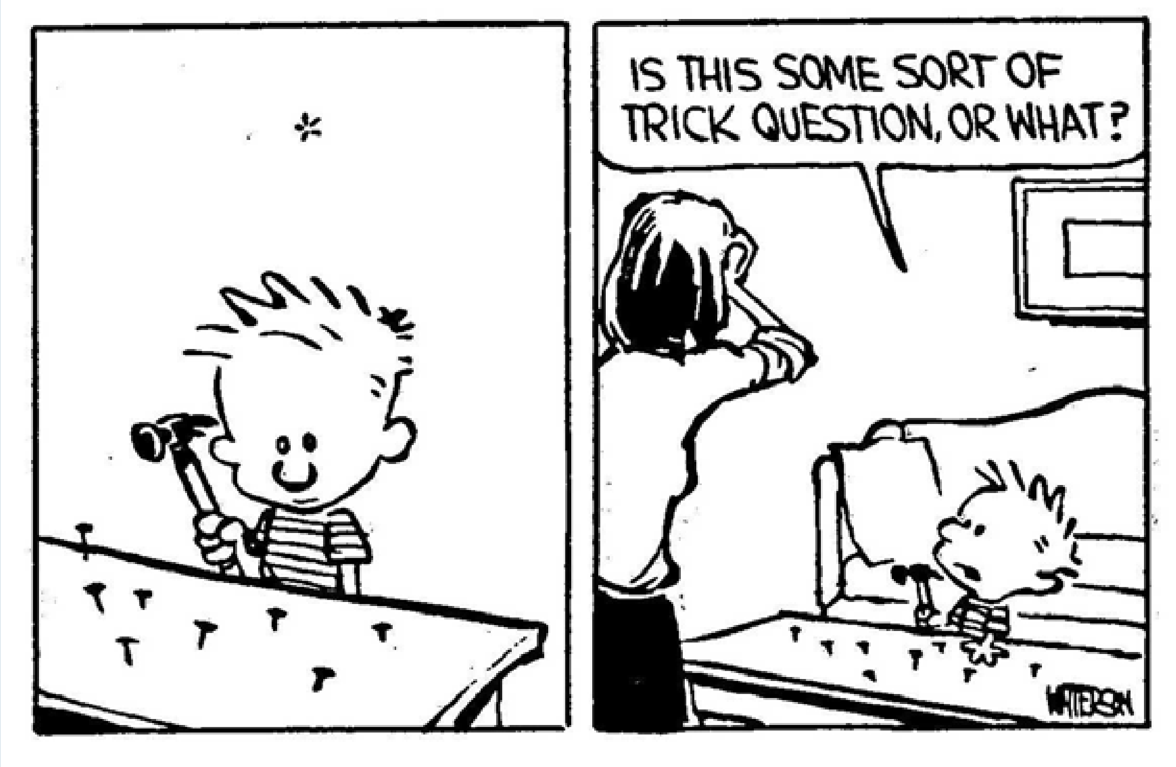
Exploring the Role of Learning on Technology Penetration - With Learning
Electricity Expenditures in 2032: $390 billion
US Electricity Use (TWh)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2002
2005
2008
2011
2014
2017
2020
2023
2026
2029
2032
Existing Capital Stock
Defender Technology
Challenger Technology
Advanced Challenger
Efficiency


Exploring the Role of Learning on Technology Penetration - With Learning and End Use Efficiency Investments
Electricity and Efficiency Expenditures in 2032: $350 billion
US Electricity Use (TWh)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2002
2005
2008
2011
2014
2017
2020
2023
2026
2029
2032
Existing Capital Stock
Defender Technology
Challenger Technology
Advanced Challenger
Efficiency


Exploring the Role of Learning on Technology Penetration - With Learning, End Use Efficiency Investments, and Non-Energy Benefits
Electricity and Efficiency Expenditures in 2032: $269 billion
US Electricity Use (TWh)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2002
2005
2008
2011
2014
2017
2020
2023
2026
2029
2032
Existing Capital Stock
Defender Technology
Challenger Technology
Advanced Challenger
Efficiency

And Yet this Question. . . .




IS THIS SOME SORT OF TRICK QUESTION, OR WHAT?
WATTERSON

No attempt here to pose trick questions, but the findings have significant implications for. . .

- Energy-Economic models
- Economic impact assessment of energy technology scenarios
- Corporate capital improvement strategies
- Evaluation tools that more properly capture the value of non-energy benefits
  - all of which begins with better data, documentation, and assessment methods.

Preliminary Conclusions

- Learning and non-energy benefits can significantly impact both technology costs and resulting market share
- A balanced learning and non-energy benefits assessment for both end-use and supply-side technologies suggests that efficiency technologies may limit the penetration of new supply-side technologies (at least compared to standard technology assessments).
- At the same time, including environmental externalities and realistic market constraints may allow new supply technologies to more fully penetrate than shown in this heuristic exercise.
- The macroeconomic benefits are still incomplete under this assessment, however. Even if technology choice algorithms are improved, energy policy models will still need to pass the full spectrum of costs and benefits to the appropriate. macroeconomic module. This is more difficult than it appears — for non-energy benefits, and especially for externalities.
- ***A major caveat:*** although the scenario descriptions presented here are reasonable illustrations of expected impacts, the evidence is still sufficiently weak that final conclusions are premature.

The difficulty lies not with the new ideas, but in escaping the old ones

John Maynard Keynes

For more information on the material referenced in this presentation, contact:

John A. "Skip" Laitner
EPA Office of Atmospheric Programs
1200 Pennsylvania Avenue NW, MS-6201-J
Washington, DC 20460
o: +1 (202) 564-9833
f: +1 (202) 565-2147
email: Laitner.Skip@epa.gov